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Book of Abstracts
November 2-5, 1998

Kellie Ann Beall, Editor

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Gaithersburg, Maryland 20899

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Comparison of the Behavior of Foams and Gels Exposed to Fire

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Introduction: Water is the principal component of both foams and gels used as fire protection agents. The foam is expanded to several times its original liquid volume with air. Data from a previous study show that, when the foam is subjected to a radiant heat input of 18 kW/m^2, the peak of the radiant heat absorption is at about 30 mm in the depth of the foam layer while radiant heat penetrates to depths up to 60 mm [1]. The reason for this behavior is the decreasing density of the foam near its exposed surface as the water is evaporated away from the foam matrix. As the density decrease, so does the extinction coefficient leading to lower absorption of the incoming radiation. In the depth of the foam layer, as the thickness and the density both increase, the radiant heat is absorbed causing the water to vaporize in-situ since the contribution of thermal diffusion is small. In contrast with this phenomenology, the behavior of the gel, in a similar situation, is dominated by thermal diffusion [2]. The radiant heat input is absorbed in the immediate proximity of the gel surface and the exposed surface approaches saturation conditions for the duration of the transient. These differences result in significantly different fire protection behaviors. These observations complemented with other, more qualitative considerations will identify a rationale for recommending the proper agent for the specific fire protection scenario.

Apparatus: A series of experiments are conducted with the Radiant Exposure Apparatus (REA), developed in the Building and Fire Laboratory of the National Institute of Standards and Technology. In the REA, two vertical gas-fired panels, 0.38 m wide and 0.83 m high, are used to supply the radiant heat input. The flame is obtained from a regulated mixture of natural gas and air fed to the two panels which are oriented at a 120° angle from each other. They are capable of generating uniform heat fluxes at the sample surface of up to 18 kW/m^2. The sample is square in shape (0.3 m each side). Thermocouples are placed on its surface at various locations. Two flux gages are mounted on the sides of the sample to monitor the heat flux level during the test.

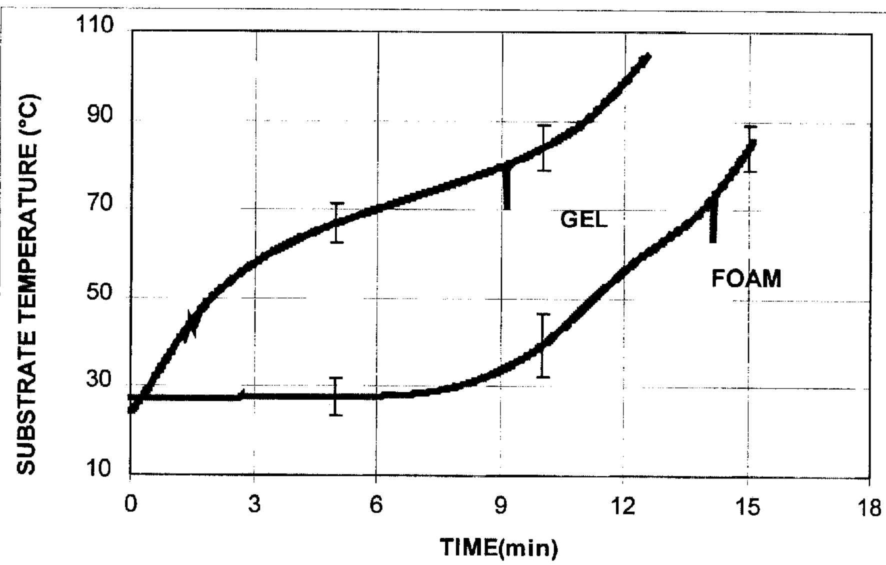

Figure 1 - Comparison of gel and foam on wood substrate.

Results: Figure 1 illustrates the behavior of the foam in comparison with the gel. Both curves are for the average surface temperature of Plywood samples (T1-11) with a radiant heat flux of 18 kW/m^2. The wood is kept at controlled temperature (23°C) and relative humidity (40%) prior to the test. The gelling agent concentration used is

6% and the thickness of the applied layer is 5 mm. The foam is obtained from a 3% liquid solution expanded twenty times with air that results in an initial foam density of 50 kg/m^3. The foam layer thickness is of 0.1 m. In both cases, the amount of water applied per unit surface area of the sample is 5 kg/m^2. Therefore, the comparison of the performance of the foam and gel is based on the same amount of water content for sample unit surface. The temperature at the sample surface exhibits a completely different behavior for these two agents. For several minutes, there is no indication that the sample coated with foam is exposed to radiant heat input. This is due to the strong insulating effect of the foam which exhibits very low thermal diffusion transport. Recall that the radiant energy is absorbed in the depth of the foam layer and that it propagates up to 60 mm into it. Considering that the foam layer is evaporated at about 0.1 mm/s, it follows that the forefront of the radiant heat wave reaches the sample as 40 mm of foam are evaporated from the original 0.1 m layer. This would take place in about 7 minutes. This coarse prediction is consistent with the measurements shown in the figure. Thereafter, the heat-up transient is steeper than for the sample coated with gel. The foam is completely evaporated in about 14 minutes. The vertical lines at 9 and 14 minutes indicate the failure of the protective layer and represent the end of the protective time. Note that the foam provides about 5 minutes of additional protective time. Consider that the longer duration of the foam protection layer (compared with the gel) must be carefully weighted against the wind effect present in the field which will reduce the foam protection time by disrupting the foam layer as its density decreases. This effect may result in a comparable overall performance of the two agents.

Conclusions: The gel is best suited for urban applications because:

a) extensive smooth surfaces (such as windows) are easily coated and the structural characteristics of the gel layer insure reliable protection;

b) the higher temperatures of the substrate are well within the limit of typical building exterior materials;

c) the gel is not greatly affect by wind;

d) the relatively simpler geometrical characteristics of the urban setting do not require the filling action of the foam.

The foam is best suited for forestry applications or for urban-wild-life settings because:

a) it keeps the substrate (which in this case is living vegetation) at ambient temperature completely shielding it from the fire radiation;

b) exhibits excellent coating and gap-filling properties for applications where the surfaces are irregular (such as trees and bushes);

c) its drawbacks are due to the limited adhesion to smooth surfaces and to the effect of wind (the wind may easily shear the low-density foam on the outer portion of the layer).

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